Renewable and Sustainable Energy Reviews 16 (2012) 4157–4164

Contents lists available at SciVerse ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Agriculture's contribution to the renewable energy sector: Policy and economics – Do they add up?

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ARTICLE INFO

Article history:
Received 31 January 2012
Received in revised form 27 February 2012
Accepted 2 March 2012
Available online 28 April 2012

Keywords:
FIT policy
Eligible technology scale
Renewable energy implementation
Agriculture

ABSTRACT

This paper reviews on-farm renewable energy (RE) production and the associated feed-in tariff (FIT) policies in Germany, USA, Canada, Denmark and the Netherlands and the impact these policies have on Renewable energy implementation with particular focus on agricultural lands. A recent FIT policy implemented in Nova Scotia is examined and used as a case study to assess the potential affect these policies might be expected to have on RE implementation within the province. Several scenarios are developed based on the existing policy structure to provide a critical review of the policy and to identify potential modifications that might provide an increase in the implementation of RE.

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1. Introduction

There is an explicit relationship between renewable energy (RE) policy goals, programs and technologies implemented in a region, which is usually determined by the values, energy profile and infrastructure of the locale [1]. A feed-in tariff (FIT) is a policy mechanism that is used to stimulate investment in RE technologies and is one of the most successful types of RE policies employed in the European Union [2]. FITs encourage RE investment by providing financial incentives at a fixed rate per energy unit for a fixed period of time. This creates investor confidence by guaranteeing rates and minimizing investor risks [3–5]. Some of the characteristics that can influence the rate of the tariff include: technology type, size or application, resource or site, length of payments, how often the policy is reviewed, inflation, adjustment and degression [6–8]. Wile and Corscadden [9] found that successful FITs must provide a reasonable return on investment (ROI) of at least five percent above the generation costs. Tariff rates can also be chosen to stimulate investment in an individual technology [4], since a higher rate provides more incentive for investment in certain RE projects,

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1364-0321/$ – see front matter.
doi:10.1016/j.rser.2012.03.027

however a tariff that is set too high is costly to society and can be a burden to electrical consumers [3,10]. Söderholm and Klaassen [11] have reported that tariffs which are set too high can actually promote installations in areas of low resources (i.e. low wind speeds), reducing the incentive for investors to minimize project costs.

The concept of a FIT policy is simple, yet developing a FIT policy proves to be a difficult process due to competing policy objectives such as maximizing renewable energy generation, reducing greenhouse gas (GHG) emissions, encouraging investor uptake while minimizing the cost to the rate payer. Most successful FIT policies tend to base tariffs on generation costs [3,5]. Factors considered when setting rates include capital investment and associated costs (licensing etc.), operating and maintenance costs, inflation, interest rates, profit margins and investor confidence [10].

Major challenges associated with determining FIT rates include upfront administrative costs, ensuring rates will not be too high or too low to encourage or discourage investor development and ensuring the policy is simple enough to encourage investors while at the same time allowing for periodic revisions, inflation and degression within the policy. Degression occurs when tariffs are reduced periodically to account for a decrease in costs over time [12] due to the decrease in technology costs as the technologies mature and implementation increases.

Another challenge with setting FIT rates is controlling the total cost of the tariff to society. The cost of the FIT program is usually weighed against economic benefits and the impact new jobs will have on the economy. Capacity limits can be implemented to mitigate the risks of an expensive FIT policy and policies need to be reviewed and updated regularly to ensure the tariff is meeting the policy's objectives [10]. Revision is typically performed either periodically or adjusted when capacity targets are reached.

1.1. FIT policy and agriculture

There has been limited research preformed on the impact that FITs have had on individual economic sectors or stakeholder groups. The majority of the literature use total installed capacity as a measure of success for a policy. However it can be beneficial to consider the installed capacity by an individual sector, to determine the effect the policy has on different stakeholders in the economy (i.e. consumers, business, farmers etc.). Toke et al. [13] found that the countries that were most successful in local ownership of wind projects (i.e. Germany, Denmark, the Netherlands) have implemented FITs. This section focuses on the impact FITs can have on the agricultural sector, through on-farm renewable energy implementation.

Germany has one of the most established FIT policies worldwide. Farmers owned 9% of the total renewable energy sources in 2009 in Germany [14], primarily through wind and solar installations. German farmers owned nearly 50% of the 16,000 MW of installed capacity in 2004 [15] and had nearly 1000 MW of installed solar PV capacity in 2009, representing almost one third of the total solar PV installed in the country [16]. Currently, there is over 22 GW of installed PV on barn rooftops [17]. In addition to solar PV, German farmers owned about 75% of the total installed wind capacity, some 6500 MW [18], and are primarily responsible for land that is leased to investors for wind farm installation. Germany also actively cultivates crops for biogas with almost 2 million acres (12%) of arable land used for energy crops [19]. It has been suggested by Hambrick et al. [17] that the success of farm uptake in Germany has been due to successful policy implementation, support from farm co-ops and lobbying groups, rural community engagement and financial institutions awareness and understanding of RE projects.

Denmark is another country that has successfully implemented a FIT that has substantial agricultural participation, with 64% of wind turbines owned by farmers [13] and over 60 small farm biogas plants, in addition to 20 large, jointly owned renewable projects (with farmers and investors) in 2003[20]. Other European countries have experienced similar uptake, for example in Austria 6% of farms were involved in RE production in 2005 [21] with 100 biogas plants in operation in 2002[22], and in the Netherlands, farmers owned 60% of the installed wind turbines in 2008 [13].

European countries adopted FIT policies many years before they appeared in North America where neither the United States (US) or Canada has a national FIT policy. In the US, Florida, Washington State and California have FIT policies and other states such as Oregon, Vermont and Wisconsin have utility run production based incentives similar to FIT policies [23]. However, in the US, biogas is the major agricultural based RE source with farmers owning only 1.8%, or 6387MW of the total 35,170MW installed RE capacity [17] and 30% of domestic corn production is used for ethanol [24]. There is no substantial solar PV industry as incentives for farmers are lacking in this area. In relation to wind energy, there appears to be a preference among farmers to lease land to wind investors in order to mitigate risks, costs and tax implications [25].

Canada has recently implemented FIT policies in two provinces: Ontario and Nova Scotia. These FITs policies are relatively new and have different tariff rates, with Ontario favoring solar energy. The impact of these policies on the agricultural industry has yet to be determined. There is however incentives for farmers to participate in Ontario's FIT through a "community adder" which provides a one cent per kilowatt hour supplement in addition to the current rates [26]. There are no specific incentives for agricultural participation in NS, leading to the focus of this paper: to review and analyze the newly implemented FIT policy in NS and to consider the potential impact this will have on the uptake of renewable technology.

1.2. Description of renewable energy policy in NS

Nova Scotia is a small Eastern Canadian province with a population of just under 1 million [27]. The provincial government have set admirable yet ambitious environmental and energy targets of reduced greenhouse gas emissions to 10% below 1990 levels by 2020 [28] and to have 25% and 40% of electricity produced by renewable sources by 2015 and 2020, respectively [29]. Historically, there has been little support for renewable electricity generation in the province, which has led to modest uptake of projects. Before 2010, the only support mechanism for small scale project was through a net metering program implemented by Nova Scotia Power Inc. – the province's monopoly for electrical supply. This regulation allowed consumers to implement small renewable energy projects with the electricity generated from the renewable energy sources used to offset energy consumed. Therefore the consumer paid for the "net" (electricity consumed less electricity produced) amount used [30]. The downfall of this regulation was that if a consumer produced more electricity than they consumed in a year, the consumer was not compensated for their over production and the surplus electricity went back onto the grid. However, if a consumer produced less than they required, the extra electricity needed was supplied by NSPI, at a cost to the consumer. The net metering regulation only applied to small projects with a generating capacity of less than 100 kW and did not provide payment for excess power generated. This policy also did not allow excess electricity generated to be supplied to surrounding community members [30].

On April 23rd, 2010 the provincial government announced the Renewable Electricity Plan that outlined the methods by which the

Table 1
COMFIT rates for approved technologies.

Technology	FIT rate ($/MWh)	Rate guaranteed for (years)
Small Wind (≤50 kW)	499	20
Large Wind (≥50 kW)	131	20
Biomass	175	20
Small scale in-stream tidal	652	20
In-stream tidal	140	20

government will move forward with regards to electricity generation [29]. Three scales of renewable electricity generation were addressed in this plan. Small scale through enhanced net metering, Community scale through a community feed in tariff (COMFIT) and large scale through NSPI and independent power producers [31]. Enhanced net metering applies to projects of less than 1 Mega Watt (MW) to be connected to the distribution network, where consumers will be paid for excess generation, but the consumer can only install a generator with sufficient capacity to meet the average annual energy consumption at their location. COMFIT addresses medium scale RE generation, and applies to projects ranging from 2 MW to 5 MW in size, with a total cap of 100 MW, connected to the distribution network; and medium and large scale renewable projects continue as they traditionally have with the Utility and Review Board overseeing NSPI's proposed projects and independent power producers bidding for projects through requests for proposals.

This paper will focus on the recently announced COMFIT policy, that has been introduced to facilitate the installation of renewable technology and help meet the environmental and energy generation targets. There are two alternative streams, for medium scale renewable energy generation: a tidal array FIT and a community based FIT, better known as the COMFIT. The tidal array tariff applies to in stream tidal projects greater than 0.5 MW and there are no restrictions on applicants. The focus of this paper however is on the COMFIT policy. As the name suggests, COMFIT aims to support community based groups including municipalities, Mi'kmaq band councils, co-operatives, not-for-profit organizations, community economic developments investment funds (CEDIFs), universities and combined heat and power biomass facilities. Table 1 displays the current COMFIT rates and guaranteed length for approved technologies in NS.

The rates listed in Table 1 demonstrate the province's encouragement for small wind and small scale in-stream tidal, however tidal technology is in the early development stages and it is thought that the high rate for tidal is to encourage research for this technology. This paper will focus specifically on small wind and the associated regulations. The province's motive for distinguishing between "large" wind and "small wind" was based on technology costs and return on equity for investors [32], and small wind is designed to encourage involvement by communities. "Small wind" is considered wind projects with a nameplate capacity of less than 50 kW, with the generation output defined at a standardized wind speed of 11 m/s and a turbine swept area of less than 200 m^2 [33]. The government have adopted as eligible technology, those turbines that are certified by the New York State Energy Research and Development Authority [34]. Eligible turbines include eight turbines rated at less than 10 kW, five turbines rated between 10 kW and 20 kW and only two turbines rated between 20 kW and 50 kW (Appendix A). After June 30, 2012, turbines must be certified through the small wind certification council [35], which is an independent certification body used by the American Wind Energy Association (AWEA) to standardize the reporting of turbine performance data in compliance with the AWEA Small Wind Turbine Performance and Safety Standard [31].

In addition to turbine eligibility, there is a 5 MW provincial cap on small wind projects, which based on the technology restrictions suggest a total of 100 small wind projects in the province (at a nameplate output of 50 kW per turbine), with a maximum of five wind projects per county and a maximum of three turbines per project [36].

The agricultural sector has proven to be a substantial investor in RE projects in European countries, however with the COMFIT restrictions in Nova Scotia, farmers can only participate through the formation of a cooperative which must include at least 25 members and the members must reside within the same municipality. This imposes a considerable barrier for farmer participation in Nova Scotia. A survey conducted by the Nova Scotia Federation of Agriculture however has identified significant interest from the farming community with fifty-two farms currently participating in wind assessment projects [37].

1.3. Method of analysis

This paper considers the impact of technical and regulatory barriers imposed by the COMFIT policy on the agricultural sector. The results of the NSFA survey and subsequent lack of project participation indicate the impact of the restriction that participants are required to form cooperatives. In order to evaluate the impact of technical restrictions, three scenarios have been developed which will demonstrate the energy output, cost and potential impact of three different turbines based on the COMFIT rates. The turbines selected for the scenarios are: the Endurance E3120, manufactured by Endurance Wind Power, which has a nameplate value of 50 kWs and is currently not an eligible COMFIT turbine due to the swept area size exceeding 200 m^2; the AOC 15/50 which has a nameplate value of 50 kW is manufactured by Seaforth Energy Inc. and is eligible for COMFIT; and the Northwind 100 Turbine, which has a nameplate value of 100 kW, is manufactured by Northern Power Systems and is currently not approved for COMFIT small wind projects due the nameplate capacity exceeding the 50 kW size limit. The Endurance E3120 and the Northwind 100 are however both eligible for the large wind tariff of $131/MWh. To ensure a common analysis platform, a renewable energy assessment program developed by Natural Resources Canada is used, RETScreen Clean Energy Project Analysis Software [38]. Retscreen is a decision support tool used to evaluate energy production and savings, costs, emission reductions, financial viability and risk for various types of Renewable-energy and Energy-efficient Technologies (RETs).

The three scenarios have been developed to consider four characteristics:

(1) The variance between the actual energy output versus nameplate capacity
(2) To determine COMFIT costs to consumer for various technology
(3) To identify the potential GHG offset from COMFIT installations using different technology
(4) To provide an estimate of IRR for each technology

Three scenarios will be presented to address objectives 2 through 4:

Scenario 1 presents the results using the current COMFIT rates for the three turbines: $499/MWh (the small wind rate) for the AOC 15/50 turbine and $131/MWh (the large wind rate) for the Endurance E3120 and Northwind 100 turbines.

Scenario 2 presents the results assuming all three turbines were eligible for small wind rates ($499/MWh).

Table 2
Variance in turbine output from the manufacturer's nameplate capacity, rated output at a standardized wind speed of 11 m/s and output for a Nova Scotia wind site of 5.5 m/s for various turbine models.

	Manufacturers nameplate (kW)	Swept area (m^2)	Manufacturers rated output at 11 m/s (kW)	CF at 11 m/s (%)	Manufacturers rated output at 5.5 m/s (kW)	CF at 5.5 m/s (%)
Endurance E3120	50	289.45	48.8	55.8	11.65	27.1
AOC 15/50	50	176.53	42.4	60.4	6.65	29.8
Northwind 100	100	347.21	77.7	51.3	13.7	18.0

Scenario 3 presents an advanced FIT to calculate FIT rates for each turbine that would not create an additional financial burden to the consumer and still be attractive to investors.

An average wind speed of 5.5 m/s is assumed in Truro NS and each scenario uses one of the three turbines to generate the 5MW of small wind capacity available. The remaining assumptions used for the scenarios can be found in Appendix B.

2. Results

The results in Table 2 show the output of each of the three models at the standard evaluation wind speed of 11 m/s and the assumed average annual wind speed of 5.5 m/s. The first objective is to demonstrate the variance between the actual energy outputs versus nameplate capacity.

Currently to be eligible for "small wind", the COMFIT regulations stipulate that turbines must have a generating capacity of 50 kW or less at a wind speed of 11 m/s, with a swept area of less than 200 m^2. As illustrated by Table 2, turbine output at a standardized wind speed of 11 m/is not always equivalent to the output indicated by the nameplate capacity of the turbine, this is due to the lack of standardized criteria when manufacturers established nameplate capacity. The Northwind 100 has a nameplate capacity of 100 kW yet it is only generates 77.7 kW at 11 m/s, this is due to the fact that the Northwind 100 has been rated at a wind speed of 14.5 m/s [39]. The AOC 15/50 turbine is considered a 50 kW turbine but it only generates 42.4 kW at 11 m/s [40] and the Endurance E3120 rated at 50 kW produces 48.8 kW at 11 m/s, but has a swept area of 289 m^2 [41]. The results in Table 2 demonstrate the variance between manufacturer's nameplate capacity and generation capacity based on a standardized method using a standard wind speed of 11 m/s which is currently being used. In addition, actual generation output at 11 m/s and output at a more typical wind speed, which in this case has been selected at 5.5 m/s vary substantially. Capacity factor (CF) is the term used to provide a measure of expected output for a particular turbine given an average annual wind speed and is sometimes referred to as the efficiency [16]. Capacity factor is defined as the ratio of actual energy output to potential energy output if operating at full capacity, for a given time period, Eq. (1):

$$\text{Capacity factor} = \frac{\text{Actual annual energy produced (kWh)}}{8760\,\text{h} \times \text{Rated capacity (kW)}} \tag{1}$$

It should also be noted that using a nameplate capacity at a higher wind speed than 11 m/s will actually result in a lower capacity factor at a given wind speed, which may result in the appearance that a turbine is less efficient.

2.1. Scenario 1

The second objective of the analysis is to determine the consumer costs for various technologies under the COMFIT program. Table 3 shows the costs for the three turbine models used in scenario 1. It is assumed that the cost to the consumer is the additional cost above the current residential electrical rate. FIT costs are calculated using the current COMFIT rates of \$0.499/kWh for small wind turbines (Endurance E3120 and AOC 15/50) and \$0.131/kWh for the large Northwind 100 turbine. Using the nameplate capacity of 100 kW, only fifty Northwind 100 turbines are required to meet the 5 MW provincial cap. At an average wind speed of 5.5 m/s. and using the lower rate of \$0.131/kwh, it would only cost consumers \$1.02 million to implement the COMFIT program using this turbine. However it is questionable whether the rate of \$0.131/kWh would be attractive for investors. The results listed in Table 3 show that a simple payback period for this investment would be over 40 years. If the E-3120 is used at a nameplate capacity of 50 kW, then 100 turbines would be required to meet the 5MW cap. As shown, it is cheaper to the consumer to implement large turbines at the lower rate of \$0.131/kWh, as it would only cost the province \$1.028 million to implement 5 MW of the Northwind 100 turbine and \$1.559 million for the Endurance E3120 turbine, whereas the cost for the AOC 15/50 is \$4.341 million. The additional cost to the consumer is calculated assuming 490,000 consumers in the province [42] and a current electrical rate of \$0.119/kWh, Eq. (2):

$$\text{Additional consumer cost} = \frac{\text{Generation from 5 MW installed capacity} \times (\text{COMFIT rate} - \text{Current rate})}{\text{Number of electrical consumers}} \tag{2}$$

As shown the annual additional consumer cost for the Endurance E3120 and the Northwind 100 is miniscule at \$0.29 and \$0.19, respectively. The additional consumer cost for the AOC 15/50 is also very small at only \$6.75 per year.

The third objective was to identify the potential GHG offset from the COMFIT installations for each of the three turbines. RETScreen software provides estimates of emission reduction and considers three main GHGs: carbon dioxide (CO_2), methane (CH_4) and nitrous

Table 3
Output, cost, offset GHG, additional consumer costs for three turbines implemented in Truro NS at a height of 30 m and average wind speed of 5.5 m/s at current COMFIT rates.

Turbine	Output (GWH from 5 MW)	FIT cost for 5 MW installed (million \$)	Additional consumer cost (\$ per consumer per year)	Offset GHG for 5 MW installed	Simple payback (years)	IRR at a wind speed of 5 m/s (%)
Endurance E3120	11.9	1.559	0.29	8570	16.1	negative
AOC15/50	8.7	4.341	6.75	6470	9.5	9.4
Northwind 100	13.7	1.028	0.19	5685	41.8	negative

Table 4
Output, cost, offset GHG, additional consumer costs for three turbines implemented in Truro NS at a height of 30 m and average wind speed of 5.5 m/s at small scale COMFIT rates.

Turbine	Output (GWH from 5 MW)	FIT cost for 5 MW installed (million $)	Additional consumer cost (cents per kW)	Offset GHG for 5 MW installed	Simple payback (years)	IRR at a wind speed of 5 m/s (%)
E-3120	11.9	5.938	9.23	8570	4.2	45.0
AOC 15/50	8.7	4.341	6.75	6470	9.5	9.4
Northwind 100	13.7	3.917	6.09	5685	7.0	20.6

oxide (N_2O). The baseline assumption is that the GHGs offset are for the Nova Scotia region, which primarily uses coal for electricity generation. Since coal is a significant contributor to GHG emissions it is a contributing factor to the high renewable targets set for the province, as any electricity generated by wind offsets electricity generated by coal and results in significant GHG reductions. As demonstrated in Table 3, the Endurance E3120 is more expensive to society, resulting in increased output and more GHG offset with 8750 tCO2 equivalents offset by the Endurance E3120 and only 6470 tCO2 equivalents offset by the AOC 15/50. The Northwind 100 would result in 5685 tCO2 equivalents offset by 5 MW of installed capacity

The fourth objective was to provide an estimated IRR for each technology. IRR is often used to determine the attractiveness of a capital investment to an investor. The higher the IRR, the more attractive the investment is. As shown in Table 3, The AOC 15/50 is the only turbine with a positive IRR at 9.4%, and the Endurance E3120 and Northwind 100 turbines are not attractive to investors with negative IRRs, meaning investors will not make money over the lifetime of this investment. Therefore although the Endurance E3120 and Northwind 100 turbines are less expensive for the consumer, they are expensive and investors would not opt for these projects as they both have long payback periods and negative IRRs. With this scenario, only the AOC 15/50 turbine is reasonable for both the investor and consumer, with a payback of 9.5 years and an IRR of 9.4% an additional consumer cost of $6.75 per consumer per year.

2.2. Scenario 2

Scenario 2 addresses the same three objectives but considers the effects if all three turbines were eligible for small wind rates, not just the AOC15/50. This calculates the cost at a rate of $0.499/kWh for all three turbines.

Table 4 demonstrates the effect of alleviating the size restrictions to allow all three turbines be eligible for small wind COMFIT rates of $0.499/kWh. This increased the cost to the province for five megawatts of installed capacity for both the Endurance E3120 and Northwind 100 turbines to $5.938 million and $3.917 million, respectively. The additional consumer costs also increased to $9.23 per consumer per year for the Endurance E3120 and to $6.09 per consumer per year for the Northwind 100, which makes them more than the additional cost for the AOC 15/50. Although the Endurance E3120 and Northwind 100 turbines became more expensive, they also became more appealing to investors as the Endurance E3120 turbine went from having a 16.1 year payback with a rate of $0.131/kWh to a payback of 4.2 years at $0.499/kWh. The payback for the Northwind 100 turbine also decreased from 41.8 to only 7.0 years. As well, the IRRs for the Endurance E3120 and Northwind 100 turbines are now higher than that of the AOC 15/50 since these turbines have higher generating outputs. Although this scenario is very attractive to investors, it does come at an increased cost to the province of 5.938 million for the Endurance E3120 leading to a slightly increased additional consumer cost of $9.23 annually versus the $6.75 for the AOC 15/50 annually. The output and offset GHGs have not changed from Scenario 1, therefore this scenario promotes more efficient turbines to investors but is more costly to consumers that has no effect on the output or GHG's yet drastic changes with payback and IRRs

2.3. Scenario 3

Scenario 3 presents a policy tool that has been used in other areas including Germany, France and Switzerland [43], called an advanced or sliding scale FIT. This FIT would base rates on output generation and would remove the need to have the size regulation. Also, with the advanced FIT, efficient wind turbines are promoted to investors, at no additional cost to the province or consumer. This is done by differentiating the tariff based on output generated. So as generation increases, tariff rates decrease allowing for overall cost to remain the same. However as generation increases there are additional benefits for investors to implement efficient turbines and the amount of offset GHGs increases. Typically the objective of this type of tariff is to reduce development pressure in the windiest areas, usually with a five year grace period to determine production and FIT rates. This correlates with NS's community approach to their FIT policy, as it would encourage development in all areas of the province. As well with this method, it could allow for more efficient turbines to be eligible without increasing costs to consumers as investors would receive lower rates for higher production (see Table 5).

Table 5 presents the results for Scenario 3. As shown, the cost to the province is held steady at 4.341 million (the cost of the AOC 15/50 turbine from Scenario 1), but the rates paid vary depending on output generated. The Northwind 100 would receive the highest tariff rate at $0.553/kWh and the Endurance E3120 would receive a rate of $0.365/kWh and the rate for the AOC 15/50 would remain the same at $0.499/kWh. Although the Northwind 100 would receive the highest rate payment, the Endurance E3120 turbine is the best option as it has the lowest payback period of 5.8 years and the highest IRR of 29%. As well it is the most efficient turbine and 8570 tCO2 equivalents would be offset annually. The Northwind 100 would receive the highest FIT rate at $553/MWh, but this turbine is not as attractive to investors as this larger turbine is more expensive

Table 5
Sliding Scale FIT rates to keep COMFIT costs the same to the province.

Turbine	Output (GWH from 5 MW)	FIT cost for 5 MW installed (million $)	FIT tariff rate ($/kWh)	Offset GHG for 5 MW installed	Simple payback (years)	IRR at a wind speed of 5 m/s (%)
E-3120	11.9	4.341	0.365	8570	5.8	29.0
AOC15/50	8.7	4.341	0.499	6470	9.5	5.3
Northwind 100	13.7	4.341	0.553	5685	6.2	25.3

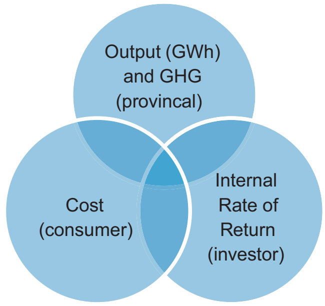

Fig. 1. Advanced FIT balance of policy objectives.

creating a payback period of 10.7 years and an IRR of 25.3%. With this method the AOC 15/50 is the least attractive option, with no change in output or investment options from Scenario 1, but still has more offset GHGs than the Northwind 100.

2.4. Discussion and suggestions

The implementation of the COMFIT policy has been beneficial for the province in terms of trying to develop and implement a renewable energy policy. Within the Renewable Energy Plan [29], it has been determined that the policy will be revised in two years after implementation, leading to the discussion of issues to be considered for amendment. The first issue relates to eligibility for ownership and the barriers to entry. Allowing small, private investors the opportunity to partake in wind investments has substantially increased wind power deployment in other countries, especially Denmark [44], yet with the current COMFIT policy, farmers are not eligible for entry unless they form a cooperative of at least 25 members. Furthermore, it has been determined that farmers typically have the resources needed for renewable energy installations (i.e. land) [45], as well it was demonstrated that farmers have been substantial investors in renewable energy in other areas of the world [14,15,18] and there are currently 52 farmers expressing interest to partake in this policy [37]. In 2010, net farm income for the province of NS was $24,804,000 [46] and there were 3795 farms in the province in 2006 [47], equating to a per farm net income of $6,535.98 per farm. A wind turbine could be a substantial means of extra income for a farmer in NS, if the current FIT rates were used with the AOC 15/50 turbine an annual income of $17,034 could be generated, or 261% of current net income could be generated by wind energy. This could be significant mode of extra earnings for NS farmers to aid in the viability and sustainability in an industry with a trend of rising input costs. Thereby excluding farmers to easily take part in this policy, the province may be losing an important group of potential investors and an opportunity to help an important economic industry. It is recommended that the COMFIT policy be amended to allow farmers to be individually eligible for COMFIT.

The second issue arising from the analysis relates to balancing competing policy objectives. Three major objectives have been considered in the scenarios: maximize renewable energy generation and GHG emissions offset, while at the same time providing a decent IRR for investors and doing so at the lowest cost to the province and consumer.

Fig. 1 highlights the competing policy objectives, with a very small window for variance within this model, because if not found in the overlapping area, not all three of the objectives will be maximized to their full potential.

To balance these objectives, the criteria for approving wind turbines should be reassessed to allow more efficient turbines based on output at a standardized wind speed (not nameplate value) and rated capacity based on capacity factor and the manufacturer's output specification. This will allow for increased output per turbine which will maximize offset GHG emissions. As well this minimizes locations needed for turbine installations which allow more prime wind speed areas to be left over for future use.

The second FIT policy objective to balance relates to IRR received by investors. A ROI of at least 5% is needed to attract investor interest [9]. The IRR has to be balanced to ensure that it is not over priced which can cause too great of a financial burden to consumers, yet it must be large enough to encourage investment. The current COMFIT rates appear to achieve this balance for the only turbine analyzed that is eligible, the AOC 15/50. However if other turbines were eligible for COMFIT there is potential for them to be even more attractive to investors, increasing the competition between wind turbine suppliers.

The third policy objective to balance is to minimize the cost to the province and consumer. As discussed with the sliding scale FIT, the cost to the province can be kept the same, yet alternative turbines can be promoted. This would allow costs to remain the same, no matter the output of the turbines, yet it promotes a range of turbines to investors, increasing the attractiveness of projects and increasing the amount of offset GHGs. It is highly recommended that a sliding scale FIT be considered when revising the current COMFIT policy.

3. Conclusions

This paper reviews the current COMFIT policy in NS as implemented through the renewable electricity plan [29]. It also provides comparison between three turbines to demonstrate the variance in nameplate values and actual turbine performance which highlights the need for a standardization of eligible turbines. The COMFIT policy is to be reviewed in 2012 and areas of improvement are suggested for consideration when amending the policy. These areas included the requirements for eligibility, where it was found farmers are not currently eligible but may prove to be substantial investors in this policy as well as revision of the policy objectives to determine exactly what the goals of the policy are. It is suggested through the analysis in this paper that a balance of three main policy objectives needs to be sought. These objectives include simultaneously maximizing generation and offset GHG emissions while encouraging investor uptake yet minimizing costs to consumers. This can prove to be tricky and it is suggested that an advanced FIT [43] may be needed to encourage efficient turbines use and continue to keep consumer costs minimized.

Appendix A.

NYSERDA approved turbines for COMFIT eligibility before June 30, 2011.

Manufacturer	Model	Rated wind speed at 11 m/s	Swept area (m^2)	NS COMFIT approved
ACSA	A 27	181.00	572.49	
Aerostar	6 meter	7.49	28.30	√
Bergey Windpower	BWC XL.1	1.00	4.90	
Bergey Windpower	BWC EXCEL-S	8.86	38.58	√
Cascade Renewable Energy	Swift Mark II	0.92	3.57	
Endurance Wind Power	S-343	5.20	31.86	√
Endurance Wind Power	E-3120 (Three phase)	54.80	289.45	
Endurance Window Power	E-3120 (single phase)	48.00	289.45	
Enertech	E13	34.00	141.19	√
Eoltec	Scirocco E5.6-6	5.72	24.69	√
Fortis	Montana 3.1 m	2.46	7.59	
Fortis	Alize 7.1 m	8.59	39.59	√
Gaia-Wind	11 kW Wind Turbine	11.80	132.35	√
Northern Power Systems	North Wind 100	77.70	347.21	
Proven Energy	Proven 7	2.50	9.64	
Proven Energy	Proven 11	6.00	23.63	√
Proven Energy	Proven 35	12.80	56.77	√
REDriven, Inc.	FD 6.4-5000	5.50	33.09	√
REDriven, Inc.	FD 8.0-10K	11.00	50.83	√
REDriven, Inc.	FD 10.0-20K	14.00	119.62	√
Seaforth Energy	AOC 15/50	42.40	176.53	√
Southwest Windpower	Whisper 200	0.98	5.91	
Southwest Windpower	Skystream 3.7	2.24	10.50	
Southwest Windpower	Whisper 500	3.00	16.41	√
Vergnet	GEV	243.00	804.04	
Wind Energy Solutions	Tulipo	2.63	19.61	
Wind Energy Solutions	WES 18	63.80	253.87	
Wind Energy Solutions	WES 30	179.00	706.14	
Wind Turbine Industries	Jacobs 31.20	16.97	70.08	√
Xzeres Wind	110	2.50	10.15	
Xzeres Wind	442	9.17	40.62	

Source: NYSERDA, [29].

Appendix B.

B.1. RETScreen assumptions

(1) Location is in Truro, N.S. with an annual wind speed of 5.5 m/s at a height of 30 m.
(2) Losses included array losses of 7%, Airfoil losses of 3%, miscellaneous losses of 5% and 94% availability.
(3) Fuel cost escalation rate, inflation rate and discount rate of 2% each.
(4) Project lifetime is assumed to be 20 years.
(5) Projects are assumed to have a debt ratio of 60%, at an interest rate of 7% for a term of 20 years.
(6) It is assumed there are 490,000 electrical consumers in the province of NS.
(7) Additional consumer cost is calculated assuming a current electrical rate of $0.119/kWh.

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